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FILTER ELEMENT

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[There are no amendments to this patent.]

Claims

1. A type of filter element characterized by the following facts: the filter element has sheet-shaped flat filter members and corrugated filter members, each of which corrugated members is prepared by folding a sheet-shaped filter member to form plural crest portions and trough portions, set alternately; on one side edge of said corrugated filter members, each corrugated filter member is folded such that its crest portions are in close contact with the

adjacent flat filter member; by means of this folding portion, the end portion of each crest portion is closed; on the other side edge, each corrugated filter member is folded such that the trough portions are in close contact with the adjacent flat filter member; by means of this folding portion, the end portion of each trough portion is closed.

2. The filter element described in Claim 1 characterized by the fact that each said folding portion is formed by folding inward so that the end surface of the folding portion becomes nearly semi-circular.

Detailed explanation of the invention

Industrial application field

This invention pertains to a type of filter element. Especially, this invention pertains to a type of filter element for use in the air cleaners of internal combustion engines.

Prior art

It is well known that elements for use in the air cleaners of internal combustion engines include a dry type and a wet type. For both types, the major filtering schemes include surface filtering and deep-layer filtering. Such air cleaner elements are required to have a filtering property for effectively removing dust or other fine particles, and to be able to maintain good filtering performance over a long period of time.

From this viewpoint, various types of elements have been developed, such as a honeycomb shaped air filter described in Japanese Kokai Utility Model No. Sho 61[1986]-200116.

Said honeycomb shaped filter element (20) has the following constitution shown in Figures 11 and 12. Flat filter members (21) and corrugated filter members (22), each of which is prepared by folding to form crest portions and trough portions, are overlapped alternately. The crest portions of corrugated filter members (22) on one side edge and the trough portions of corrugated filter members (22) on the other side edge are sealed with filling of filling sealant (23), so as to form plural flow channels, each of which has one end opened and the other end closed, between the two side edges. For said honeycomb shaped filter element (20), air as the fluid to be filtered flows through inlet (20_{IN}) indicated by the arrow into the element. Air moves within flow channels (24) formed between flat filter members (21) and corrugated filter members (22), and becomes clean as it permeates through the filtering planes of the element. The filtered air then flows out from outlet (20_{OUT}).

Problems to be solved by the invention

The aforementioned conventional honeycomb shaped air filter has some problems. As the fluid to be filtered flows into the element, as shown in Figure 12, a portion of the fluid to be filtered collides with outer end surface (23a) of filler (23), so that the air passage resistance increases. This problem also takes place when the filtered fluid flows out the clean side. That is, the filtered fluid collides with inner end surface (23b) of filling sealant (23), leading to an increase in the air passage resistance.

With regard to the filtering area, due to the aforementioned problem, the portion closed with filling sealant (23) cannot be used as a filtering plane. Consequently, the filtering area decreases, and, finally, it is hard to realize a long lifetime. This is undesired.

The objective of this invention is to solve the aforementioned problems of conventional methods by providing a type of filter element characterized by the fact that by reducing the air passage resistance of the fluid to be filtered and increasing the filtering area, it is possible to improve the filtering performance, and, at the same time, to maintain good filtering performance over a long period of time.

Means to solve the problems

In order to realize the aforementioned objective, this invention provides a type of filter element characterized by the following facts: the filter element has sheet-shaped flat filter members and corrugated filter members, each of which corrugated members is prepared by folding a sheet-shaped filter member to form plural crest portions and trough portions, set alternately; on one side edge of said corrugated filter members, each corrugated filter member is folded such that its crest portions are in close contact with the adjacent flat filter member; by means of this folding portion, the end portion of each crest portion is closed; on the other side edge, each corrugated filter member is folded such that the trough portions are in close contact with the adjacent flat filter member; by means of this folding portion, the end portion of each trough portion is closed.

Operation of the invention

According to this invention, with the aforementioned means, in a filter element composed of sheet-shaped flat filter members and corrugated filter members, each of which is prepared by folding a sheet-shaped filter member to form plural crest portions and trough portions, set alternately; on one side edge of said corrugated filter members, each corrugated filter member is folded such that its crest portions are in close contact with the adjacent flat filter member; by means of this folding portion, the end portion of each crest portion is closed; on the other side edge, each corrugated filter member is folded such that the trough portions are in close contact

with the adjacent flat filter member; by means of this folding portion, the end portion of each trough portion is closed. Consequently, there is no need to use a filling sealant to close the two end portions for each of said crest portions and trough portions. As a result, said two end portions also can be used as filtering planes. Consequently, it is possible to reduce the air passage resistance and to increase the filtering area.

Application examples

In the following, application examples of the filter element of this invention will be explained with reference to Figures 1-5.

As shown in Figures 1 and 2, for the filter element 1 of this invention, sheet-shaped flat filter members (2) and corrugated filter members (3), each of which is prepared by folding a sheet-shaped filter member to form plural crest portions (3a) and trough portions (3b), are overlapped. Said flat filter members (2) and corrugated filter members (3) are set alternately.

As shown in Figure 3, for said corrugated filter members (3), on one side edge S_L, the corrugated filter members are folded to form folding portion (4) such that end portions (3e) of their crest portions (3a) are in close contact with adjacent flat filter members (2), respectively. By means of this folding portion (4), end portion (3e) of each crest portion (3a) is closed. On other side edge S_R, the corrugated filter members are folded to form folding portion (5) such that end portions (3e) of trough portions (3b) are in close contact with adjacent flat filter members (2), respectively. By means of this folding portion (5), end portion (3e) of each trough portion (3b) is closed. In this way, folding portion (4) and folding portion (5) are folded in directions opposite one another, and they are folded inward such that end surfaces (4e), (5e) of folding portions (4), (5) have a nearly semicircular shape. As shown in Figures 1 and 2, at said folding portions (4), (5), each corrugated filter member (3) and adjacent flat filter members (2), (2) are bonded to each other with adhesive (6) to form sealing portions (7). Said sealing portions (7) are formed by bonding end surfaces (4e), (5e) of folding portions (4), (5) of corrugated filter members (3) with opposite surfaces (2a) of flat filter members (2), respectively.

By laminating to form said filter element (1) as explained above, as shown in Figure 4, a plan view, the cross-section of the element becomes a honeycomb shape, with individual chambers (8).

In the following, operation of the filter element of this invention with the aforementioned constitution will be explained.

As shown in Figures 4 and 5, air as the fluid to be filtered flows into the element through plural inlets (1_{IN}) formed in a nearly triangular shape with said flat filter members (2) and corrugated filter members (3) [and flows as] indicated by arrow A in Figure 5(a). Air flows in flow channels (10) formed between flat filter members (2) and corrugated filter members (3),

and, as it passes through the filtering planes of flat filter members (2) and corrugated filter members (3), it is filtered. The filtered air then flows from outlets (1_{OUT}) (only passage through flat filter member (2) illustrated in this figure). Also, air as the fluid to be filtered that goes straight in flow channel (10) as indicated by arrow B, passes through folding portion (5) and is filtered.

Also, as another scenario, the fluid to be filtered does not flow through inlets (1_{IN}) into the element. Instead, as indicated by arrow C in Figure 5(b), it directly passes through folding portion (4) on the inlet side of the element and is filtered, it then flows into the element, flows straight in flow channel (10), and flows from outlets (1_{OUT}).

In this way, for the filter element of this invention, on one side edge of corrugated filter members (3), folding portion (4) is formed such that crest portions (3a) are in close contact with adjacent flat filter members (2), respectively, and, on the other side edge, folding portion (5) is formed such that trough portions (3b) adjacent to said crest portions (3a) are in close contact with the adjacent flat filter members, respectively. Consequently, said folding portions (4), (5) form filtering planes, leading to a decrease in air passage resistance and an increase in the filtering area. Also, by folding the folding depth of folding portions (4), (5) more deeply, the filtering area can be further increased. Also, as shown in Figure 4, filter element (3) [sic; (1)] has a honeycomb-like cross-sectional shape. Since such honeycomb-shaped cross-section is formed, the filtering member has individual chambers (8). Said individual chambers (8) have an advantage in that they can prevent dust attached on the surface of the filtering paper from movement under the influence of the fluid. If the dust moves, a cake layer of the dust cannot be formed, and the lifetime is shorter. Since this problem can be prevented, the lifetime increases.

In the explanation for the application examples, folding portions (4), (5) have a semicircular shape. However, another shape may also be adopted as long as close contact with adjacent flat filter members (2), (2) can be realized.

In the following, examples will be explained of a vortex-shaped element, an elliptic-shaped element and a laminated element formed by winding or laminating filter elements (1) of this invention shown in Figures 1 through 5.

Vortex-shaped element E shown in Figure 6 is prepared by laminating one flat filter member (2) and one corrugated filter member (3) having folding portions (4) and (5). Then, the laminate is wound in a vortex shape on the periphery of cylindrical axial center (12), with said corrugated filter member (3) on the inner side. At folding portions (4), (5), adhesive (6) is applied to bond corrugated filter member (3) with adjacent flat filter members (2), (2).

Elliptic-shaped element E shown in Figure 7 is prepared by laminating one flat filter member (2) and one corrugated filter member (3) having folding portions (4) and (5). Then, the laminate is wound in an elliptic shape on the periphery of elliptic-shaped axial center (13), with

said corrugated filter member (3) on the inner side. At folding portions (4), (5), adhesive (6) is applied to bond corrugated filter member (3) with adjacent flat filter members (2), (2).

Laminated element E shown in Figure 8 is prepared by laminating individual flat filter members (2) and individual corrugated filter members (3) having folding portions (4) and (5), alternately. Then, at folding portions (4), (5), adhesive (6) is applied to bond each corrugated filter member (3) with adjacent flat filter members (2), (2).

Experimental results

In the following, experimental results of the filter element of this invention as compared with those of conventional filter elements will be described.

A total of 8 types of dust samples defined in JISZ8901 were used in the test, which was performed according to the method defined in JISD1612. The flow rate of the air in the test is 6.5 /min [sic; L/min].

Figure 9 is a diagram illustrating filtering efficiency (%) versus feed dust quantity (g). In this figure, the abscissa represents the feed dust quantity (g), the ordinate represents the filtering efficiency (%), the broken line indicates the results of a conventional filter element, and the solid line indicates the results of a filter element of this invention. As can be seen from Figure 9, the filtering efficiency of the filter element of this invention is more than 1% higher than that of the conventional type.

Figure 10 is a diagram illustrating the air passage resistance (mmAq) versus air flow rate (L/min). In this figure, the abscissa represents the air flow rate (L/min), the ordinate represents the air passage resistance (mmAq), the broken line indicates the results of a conventional filter element, and the solid line indicates the results of a filter element of this invention. As can be seen from Figure 10, the air passage resistance of the filter element of this invention is significantly lower than that of the conventional type.

Effect of the invention

As explained above with reference to application examples, this invention provides a type of filter element which is composed of sheet-shaped flat filter members and corrugated filter members, each of which is prepared by folding a sheet-shaped filter member to form plural crest portions and trough portions, set alternately; on one side edge of said corrugated filter members, each corrugated filter member is folded such that its crest portions are in close contact with the adjacent flat filter member; by means of this folding portion, the end portion of each crest portion is closed; on the other side edge, each corrugated filter member is folded such that the trough portions are in close contact with the adjacent flat filter member; by means of this folding portion, the end portion of each trough portion is closed. Consequently, there is no need to use an

adhesive or other filling sealer to close the two end portions of said crest portions and trough portions. Instead, said two end portions can also be used as filtering planes. Consequently, the filter element of this invention has a large filtering area, so that the filtering efficiency can be improved. Also, since the dust that can be collected per unit area of the filtering element is constant, increase in the filtering area leads to a corresponding increase in the lifetime of the element.

Also, according to this invention, when the element is evaluated at the same flow rate, since the filtering area is larger, the flow velocity of the air passing through the element decreases, leading to increase in the filtering efficiency.

In addition, because the two end portions of the crest portions and trough portions of the element of this invention are not closed with filling sealant, it is possible to reduce the air passage resistance when the air as the fluid to be filtered flows into the element and flows out to the clean side.

Brief description of the figures

Figure 1 is an oblique view illustrating a filter element of this invention. Figure 2 is a cross-sectional view of the filter element. Figure 3 is an oblique view of the corrugated filter member of the filter element. Figure 4 is a plan view of the filter element. Figure 5 is a diagram illustrating operation of the filter element. Figures 6-8 are oblique views illustrating elements using the filter element of this invention. Figures 9 and 10 are diagrams illustrating the results of tests performed for comparing the filter element of this invention with a conventional type. Figure 11 is an oblique view illustrating a conventional filter element. Figure 12 is a diagram illustrating its operation.

1 Filter element
2 Flat filter member
3 Corrugated filter member
4 Folding portion
5 Folding portion
6 Adhesive
7 Sealing portion
8 Individual chamber
10 Flow channel

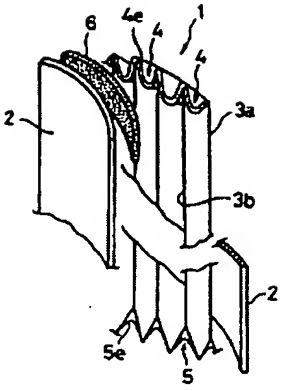

Figure 1

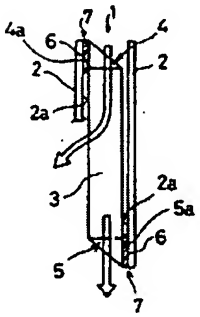

Figure 2

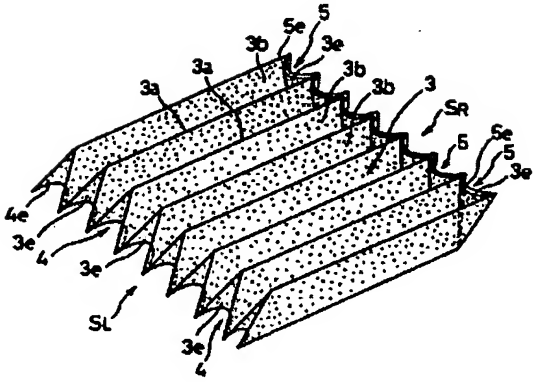

Figure 3

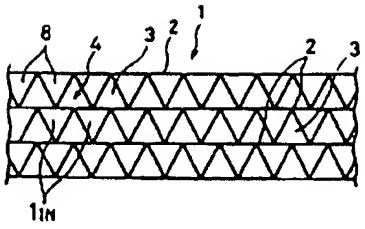

Figure 4

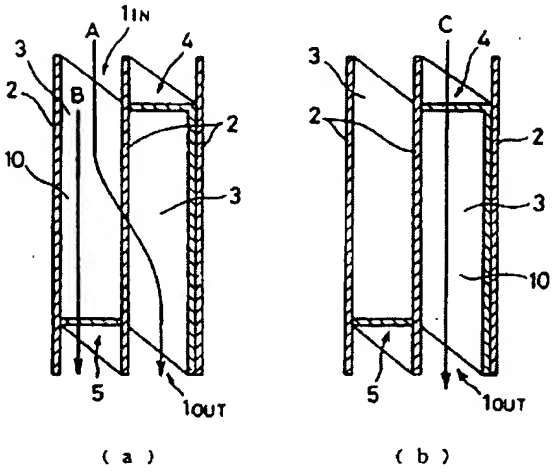

Figure 5

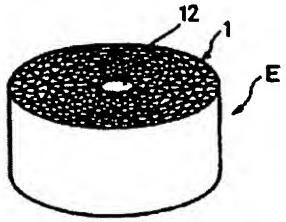

Figure 6

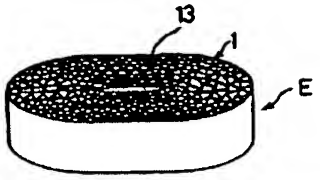

Figure 7

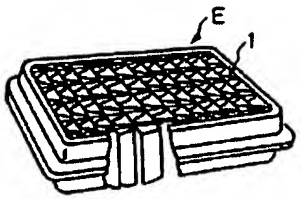

Figure 8

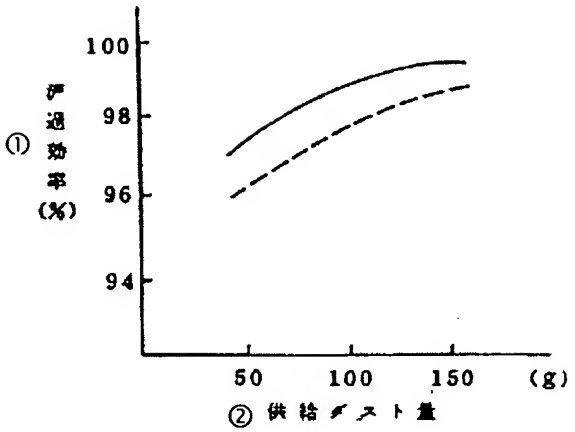

Figure 9

Key: 1 Filtering efficiency
2 Feed dust quantity

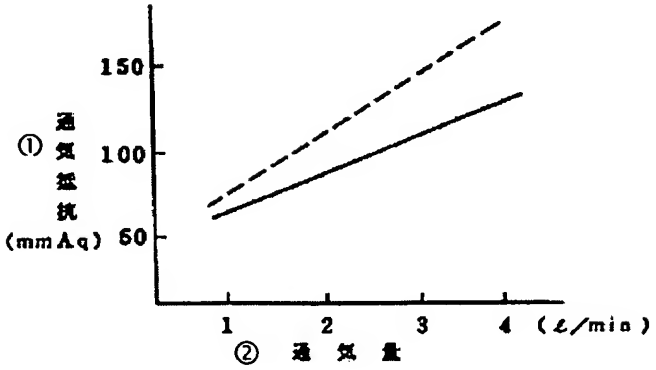

Figure 10

Key: 1 Air passage resistance
2 Air flow rate

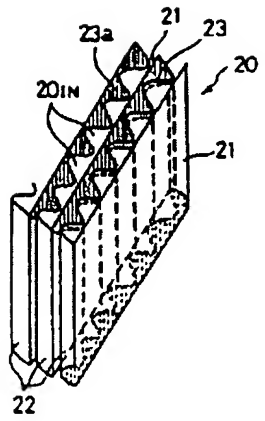

Figure 11

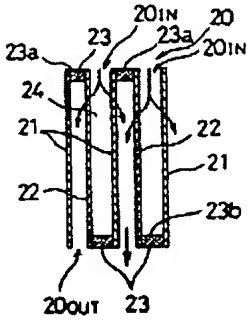

Figure 12